

Remarks

Amendments to the Claims

Independent claims 1, 67, and 72 have been amended to delete the specific recitation to “the hydride comprising lithium containing cations and the hydroxide comprising lithium containing cations.” This deletion from claims 1, 67, and 72 is believed to satisfy the rejection under 35 U.S.C. 112 with respect to these claims. In this respect - the removal of the reference to lithium-containing cations - claims 1, 67 and 72 are restored to their original text as filed.

Dependent claims 10, 11, 12, 20, 21, 73, 74, 75, and 76 are amended to delete their reference to lithium and to restore their reference to “one or more cationic species other than hydrogen.”. It is intended and believed that these claims have been returned to their original text as filed. These deletions from claims 1, 10-12, 20, 21, 67, and 72-76 were introduced into these claims in response to an Examiner’s phone call stating that the claims would be allowable if limited to lithium-containing species.

While the second restriction requirement in this case requires the presence of a lithium-containing hydride and a lithium-containing hydroxide it is not intended to limit the scope of these claims to hydrides and hydroxides that contain only lithium. For example, claims remaining in this case include lithium and boron containing hydrides, lithium and aluminum containing hydrides and lithium and aluminum containing hydroxides. And the language of the claims permits the presence of other cation-containing hydrides and hydroxides in addition to the “restriction required” lithium-containing hydrides and hydroxides.

Independent claim 1 is further amended to state that the respective portions of hydride particles and hydroxide particles are mixed together and that the first portion and second portion of hydride particles react substantially completely with the water and particles of hydroxide to form hydrogen and an oxide. As described in the specification this oxide is useful for regeneration of a hydride, hydroxide, or both in restoring the hydrogen storage medium. This amendment to claim 1 is consistent with its original dependent claims 2 and 9. The method defined in claim 1, as amended, is further supported by the text of the specification as filed as stated, for example, in paragraphs 0007-0009, 0017, 0018, 0050-0052, 0055, 0063, 0079-0084.

Paragraph 0063, for example, states that in preferred embodiments the starting materials are in particulate form and of a size related to its intended hydrogen release

performance at a given temperature. It is preferred that the starting material reactants are mixed together (e.g., homogeneously) such as by ball milling. Indeed, as stated in paragraph 0080, a compressive force may be applied to the mixture of particulate reactants. As stated in paragraphs 0081- 0082, the total amount of hydride comprises the first and second portions. The first portion of hydride is used to react with water (which may be present in a hydrated hydroxide) to produce heat to overcome the energy activation barrier of the hydrogen production reaction between a remaining portion of the intermixed hydride and a hydroxide (0081). As stated in paragraph 0084, it is preferred that the hydrogen production reaction proceeds substantially to completion and that the hydride and hydroxide reactants are consumed in the reaction to an industrially practical level as expected by one of skill in the art.

As the text of dependent claims 2 and 9 is now included in claim 1, dependent claims 2 and 9 are cancelled as unnecessary.

In addition to fully supporting the language of independent claim 1, it is believed that the above paragraphs of the specification support the text of independent claims 67 and 72.

Claims 57 and 61, dependent on dependent claim 54 and independent claim 1 are amended to clarify that the hydrated hydroxide, $\text{LiOH}\cdot\text{H}_2\text{O}$, provides at least a portion of the water and of the hydroxide specified in claim 1.

The Claim Rejections under 35 U.S.C. 112

Claims 1-88 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement.

It is intended and believed that the amendments deleting reference to lithium-containing cations in independent claims 1, 67, and 72, and in dependent claims 10, 11, 12, 20, 21, 73, 74, 75, and 76 bring the remaining claims in this application into compliance with 35 U.S.C. 112, first paragraph. It is also submitted that the above cited portions of the specification satisfy the written description requirement of each of these independent claims.

Claim 57 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. It is submitted that the amendments to claims 57 and 61 meet this rejection.

The Claim Rejections under 37 CFR 1.75(c)

Claims 6, 71 are objected to under 37 CFR 1.75(c) as being of improper dependent form for failing to further limit the subject matter of a previous claim.

Claims 6 and 71 are dependent claims that recite embodiments of the invention in which a reaction between a hydride and a hydroxide to produce hydrogen is endothermic. It appears that the basis of this objection is based on the Examiner's narrow reading of the specification in view of his restriction requirement to species in which the hydride reactant and hydroxide reactant must include lithium. The Examiner reads the specification as only illustrating endothermic reactions with respect to hydrides and hydroxides other than the specific lithium-containing hydrides and hydroxides mentioned in the specification. However, the Examiner's list of disclosed lithium-containing species overlooks $\text{LiAl}_2(\text{OH})_7 \cdot 2\text{H}_2\text{O}$ (paragraphs 0055, 0092 and claims 55 and 81). The specification states that such hydrated hydroxides may contain varying amounts of water. Further, applicants' disclosure of the hydrated lithium aluminum hydroxide, considering the thrust of the whole application, clearly amounts to a disclosure of the corresponding non-hydrated lithium aluminum hydroxide. The specification does not state that the reaction of a lithium hydride with this hydroxide or hydrated hydroxide is exothermic or endothermic.

Furthermore, even with the restriction, applicants' claims are not limited to identified lithium species and others may lead to endothermic reactions. Also, as restricted, the claims may require a lithium-containing hydride and hydroxide, but the hydride and hydroxide reactants may comprise additional species with other cations. These additional reactants may present endothermic reactions.

The Examiner is urged to reconsider and withdraw this objection.

The Claim Rejections under 35 U.S.C. 102(b) and 35 U.S.C. 103(a)

Claims 1-12, 14-29, 54-55, 57, 63-64, 67-82, 84 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Machin et al. ("Kinetics of the Reaction of Water Vapour with Crystalline Lithium Hydride").

It is respectfully requested that each of these rejections be reconsidered and withdrawn for the reasons presented below in this paper.

Claims 48, 49, 61, 65, 66, and 88 are rejected under 35 U.S.C. 103(a) as being unpatentable over Machin et al. (“Kinetics of the Reaction of Water Vapour with Crystalline Lithium Hydride”) in view of Amendola et al. (US 2004/0033194).

It is respectfully requested that each of these rejections be reconsidered and withdrawn for the reasons presented below in this paper.

The Claimed Invention

The claimed invention provides hydrogen release methods and a hydrogen storage system for producing hydrogen from a mixture of particles of a hydride and a hydroxide. Some or all of the hydroxide may be hydrated. The mixture of the hydride and hydroxide particles amounts to a hydrogen storage system which may be utilized to release substantially all available hydrogen from the mixed particulate reactive compounds. When hydrogen is needed, water is used to react with a portion of the hydride to produce heat to initiate a hydrogen-producing reaction between the remaining hydride and hydroxide particles in the mixture.

In independent method claim 1 and its dependent claims, a first portion of hydride particles are reacted with water to produce heat for a hydrogen producing reaction in a second portion of hydride particles and hydroxide particles. The portions of particles are all mixed together to utilize the heat and facilitate the solid state reaction. The amount of hydride particles is determined to react with the amount of water used and the amount of hydroxide particles to produce hydrogen and an oxide. Dependent claims 3-8, 10-12, 14, 15, 19-21, 26-29, 48, 49, 54, 55, 57, 61, and 63-66 specify features of the claim 1 method. These features include the use of water and/or a hydrated hydroxide to produce the heat for the reaction between additional hydride and hydroxide. The features of the dependent claims also include specific hydride compositions, hydroxide compositions, and hydrated hydroxide compositions.

In independent method claim 67 and its dependent claims, heat is generated in a first reaction by reacting water with a first portion of hydride particles. The first portion of hydride particles is in contact with a mixture of hydride particles and hydroxide particles which receive

the heat and are induced to react to form the hydrogen and an oxide. Dependent claims 68-71 specify additional features of the hydrogen producing method.

In independent claim 72 and its dependent claims, a hydrogen storage composition is provided. The system has a hydrogenated state in which the composition comprises a mixture of particles of a hydride and a hydrated hydroxide. The quantity of hydride is sufficient to react with the water content and hydroxide content of the hydrated hydroxide. The products produced are hydrogen and an oxide as opposed to the many other possible reaction products as seen in the Machin publication. Dependent claims 73-76, 80-82, 84, and 88 recite additional features of the hydrogen storage composition.

Neither the Machin et al kinetics publication nor any combination of Machin with the Amendola et al published application teach or suggest any of applicants' hydrogen producing methods or hydrogen storage compositions. Neither Machin nor Amendola (not any combination of them) start with a mixture of hydride particles and hydroxide particles (and/or hydrated hydroxide particles) that is formulated to substantially react fully to produce hydrogen and an oxide. Neither uses a quantity of water to react with a portion of the hydride particles in the mixture to produce heat to activate a further reaction between hydride and hydroxide particles. In contrast to Machin and Amendola, applicants' claimed practices use a reaction with water and some hydride particles to produce heat and fully utilize a remaining mixture of particulate starting materials to wring out substantially all available hydrogen and produce a useful oxide.

The Machin et al Publication and the Amendola et al application

Machin discloses a laboratory study of the reaction of water vapor with lithium hydride and observed the formation of lithium hydroxide, lithium oxide, hydrogen and other compounds depending on the conduct of the experiment. The Machin study observes and reports many reactions and reaction products resulting from reaction of water vapor and lithium hydride. The reactions occur under different conditions and utilize multiple pathways. For example, Machin teaches a reaction of LiH with LiOH to produce hydrogen in his Materials section, page 2206 and equation 22, page 2216. But the reactions are carried out at 400 C (materials section) or at > 120 C (sentence surrounding Eq. 22, page, 2216). These are system temperatures that are not practical in, for example, vehicle hydrogen storage systems and they are avoided using

applicants' claimed inventions. Machin's disclosure does not contemplate a practice of generating heat within an intimate particle mixture of hydride and hydroxide to activate the release of hydrogen and the production of an oxide.

The Machin study does not teach or suggest providing a mixture of suitable hydride particles with particles of a hydroxide (and/or hydrated hydroxide) and reacting water with a portion of the hydride particles to heat the mixture to initiate a hydrogen producing reaction between other hydride particles and hydroxide particles and/or hydrated hydroxide particles in the same mixture. For example, claim 1 states in part, "reacting a first portion of particles of a hydride with water to produce heat in a first reaction and reacting, in the solid-state, a mixture of a second portion of particles of said hydride and particles of a hydroxide in a second reaction, by transferring said heat thereto." (emphasis added)

Machin does not teach or suggest providing a sufficient quantity of hydride particles in the mixture to react with free water or hydrated hydroxide particles and to react with other hydroxides in releasing substantially all available hydrogen from the mixture and forming an oxide as a useful by product. On his page 2217, Machin mentions a reaction between $\text{LiOH} \cdot \text{H}_2\text{O}$ and LiH but the reaction product is LiOH not Li_2O , an oxide as required by applicants' claims. Machin's study does not suggest the highly productive storage and release of hydrogen as is realized in applicants' claimed invention. Machin does not disclose any of the features of any of applicants remaining claims. Accordingly, the rejections of each of claims 1-12, 14-29, 54-55, 57, 63-64, 67-82, and 84 should be withdrawn and the claims should be allowed.

Machin is then combined with Amendola to reject claims in which the hydride reactant comprises lithium borohydride. The Amendola disclosure of the use of lithium borohydride as a reactant does not combine with the Machin disclosure to suggest applicants' claimed practices of combining mixed reactive particle portions of a hydride with a hydroxide and or hydrated hydroxide as a hydrogen storage medium that is actuated for release of hydrogen and formation of a useful oxide byproduct by reaction with water. The shortcomings of the Machin disclosure as specified above are not overcome by any disclosure in Amendola. The rejection of claims 48, 48, 61, 65, 66, and 88 is not supported by any combination of the Machin and Amendola disclosures

It is requested that all rejections of claims 1, 3-8, 10-12, 14, 15, 19-21, 26-29, 48, 49, 54, 55, 57, 61, 63-76, 80-82, 84, and 88 be withdrawn, that each of these claims be allowed and this application passed to issue.

In this paper applicants have attempted to fully respond to each of the issues raised in the examination of this application. If the Examiner feels that a personal discussion could resolve any remaining issues he is invited to call applicants' attorney at the number provided below.

Respectfully Submitted,

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